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PART II

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Electricity Test Fee Schedules

Title 15—COMMERCE AND FOREIGN TRADE

Chapter II—National Bureau of Standards, Department of Commerce

SUBCHAPTER A—TEST FEE SCHEDULES

PART 201—ELECTRICITY

Under the provisions of 15 U.S.C. sections 275(a) and 277, the test fee schedules of the National Bureau of Standards, Department of Commerce, pertaining to electricity are revised as provided herein.

This revision supersedes Title 15, Chapter II, Subchapter A, Part 201, which appeared in 29 F.R. 7316, 9841, 15810, and 16319. It includes several increases of range and adds two new services; one for frequency stability calibration of signal sources, and one for continuous wave low level power measurement of coaxial bolometer units and bolometer-coupler units. The fees have generally been revised upward to assure full recovery of the cost of providing calibration services. The major new cost factor included is the impact of Federal pay legislation which took effect in July 1964.

PART 201—ELECTRICITY

NOTE: The calibration service covered by this part includes the determinations of the corrections for standard electrical and electronic measuring apparatus and their range-extending auxiliaries used at power and audio frequencies (up to 30 kHz (kc/s), high frequencies 30 kHz (kc/s) to 1000 MHz (Mc/s) and higher), and microwave frequencies (above 1000 MHz (Mc/s).

The Bureau does not test, except occasionally for other agencies of the Federal Government, electrical devices or supplies not directly related to the field of measurement. Tests of power transformers, motors, generators, relays, wiring, appliances, etc., should not be requested.

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AUTHORITY: The provisions of this Part 201 issued under sec. 9, 31 Stat. 1450, as amended; 15 U.S.C. 277; interprets or applies sec. 7, 70 Stat. 959; 15 U.S.C. 275a.

RESISTANCE MEASUREMENTS

INVOLVING PRECISION WIRE-WOUND RESISTORS

§ 201.100 General.

In general, §§ 201.101 and 201.102 apply only to apparatus embodying the following features:

(a) The resistance material should have a low temperature coefficient, should not change its resistance appreciably with time, and for low-valued coils should have a small thermoelectric power against copper.

(b) All wire standard resistors and the more important section of resistance apparatus for use in d–c circuits should be wound on metal or ceramic supports, preferably in a single layer. Electrical connections to the resistance material should be brazed in all cases in which the total resistance is less than 1,000 ohms. The resistance material should be protected against oxidation and other chemical action and should be annealed or aged by baking after winding.

(c) Precision standard resistors should be so adjusted as to give an accuracy of at least 0.02 percent without corrections. Precision resistance apparatus should be adjusted within 0.05 percent of nominal value.

(d) Because comparatively rapid changes in resistance take place in new apparatus, it is not advisable to calibrate new or repaired apparatus until at least two months after the resistors have been annealed and adjusted. Precision apparatus known to be a prototype will be held in the laboratory (in the absence of other instructions) for at least a month, when the measurements will be repeated to determine the drift in value, if any. No extra charge is made for these later measurements. Occasionally during the course of calibration it is discovered that the standard or instrument under observation is defective and in need of repair. In such instances the item in question will be rejected and a fee equal to the published fee, in whole or in part, will be assessed, commensurate with the effort expended before calibration was halted.

(e) Unless otherwise stated, the tests listed are generally made using a direct current of such magnitude as to cause only a negligible heating of the resistance material. Calibrations of standard resistors, bridges, and decade resistors consist of determinations of the resistance of the standards or of the resistance of the elements of the bridges or similar apparatus from which values corresponding to all possible readings can be computed. Precision standard resistors are ordinarily measured at a temperature of 25° C., while resistance apparatus is measured at room temperatures, usually from 22 to 25° C.

(f) The Bureau does not calibrate portable self-contained test equipment having relatively low accuracy such as portable potentiometers, resistance test sets, and double-bridge ohmmeters. The accuracy of these devices is such that a complete detailed determination of corrections is not economically feasible. Apparatus of this type may be spot-checked by measuring known voltages or resistances with them. Adequate calibration services of this type can be obtained from a number of commercial testing laboratories.

§ 201.101 Precision standard resistors.

Standards of 10 ohms and less of the precision type provided with amalgamated current terminals and designed for

oil immersion must be of the four-terminal type, that is, must have both current and potential terminals. The resistance of standards having nominal values in range 0.0001 ohm to 100,000 ohms will usually be given to the nearest 0.0001 percent in terms of the calibrating unit (the legal unit) maintained by the Bureau with a group of 1-ohm standard resistors. Each report of calibration will state the uncertainty of the reported value at the time of calibration. This uncertainty will vary from 0.0001 percent for Thomas-type 1-ohm standards to 0.002 percent for resistors of nominal value 0.0001 ohm. Additional information regarding standard resistors (is included with) the report of calibration.

Item	Description	Fee
	Determination of resistance in oil bath at 25° C. For all standards having resistances in the range 0.0001 to 100,000 ohms, inclusive, provided thay are adjusted with 0.05 percent of a nominal value which is itself a decimal multiple (or submultiple) of 1 ohm:	
201.101a-1	Two-terminal measurements	$40.00
201.101a-2	Four-terminal measurements 0.01 ohm to 10 ohms (except Thomas type)	50.00
201.101a-3	Four-terminal measurements, Thomas-type 1 ohm and standards 0.001 ohm and less	70.00
	Determination of resistance in oil bath at 25° C. For odd-valued standards not falling within the scope of item 201.101a:	
201.101b-1	Two-terminal measurements	65.00
201.101b-2	Four-terminal measurements	75.00
	Measurement of resistance in oil bath at 20, 25, and 30° C., and determination of temperature coefficient. Such measurements are made only when it is shown that the small changes in resistance resulting from necessary variations of the temperature from 25° C. are of importance:	
201.101c-1	Two-terminal measurements	160.00
201.101c-2	Four-terminal measurements	175.00
201.101z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged dependent on the time involved in making the tests.	

§ 201.102 Precision resistance apparatus.

Corrections pertinent to apparatus of suitable quality submitted under this section will ordinarily be reported to a number of significant figures so chosen that normal variation of ambient conditions within the stated bounds of test conditions will not affect the corrections by more than a few units in the last place reported. Calibrations will be made at room temperature, usually 22 to 25° C.

Item	Description	Fee
201.102a	Precision decade and plug boxes. For decades not exceeding 10,000 ohms per step:	
	(1) First point in each box	$20.00
	(2) Each additional point in same resistance box	5.00
201.102b	Megohm box, 10 sections each 100,000 ohms	195.00
201.102c	Megohm boxes, wire-wound, 10 equal sections. Calibrations with all sections in parallel giving nominal value 0.01 to 10 megohms	70.00
201.102d-1	Precision Wheatstone bridges	520.00
201.102d-2	Calorimetric bridges of all kinds	705.00
201.102e	Potentiometers, minimum steps 10 μV or more	300.00
201.102f	Potentiometers, minimum steps less than 10 μV	555.00
201.102g	Kelvin bridge ratio box	$215.00
201.102h	Double ratio set for Kelvin bridge, with double set of fixed and variable arms	630.00
201.102i-1	Four-dial precision resistive voltage divider	350.00
201.102i-2	Five-dial precision resistive voltage divider	435.00
201.102i-3	Six-dial precision resistive voltage divider or universal ratio set	475.00
201.102j	Quick resistance ratio test on any precision voltage divider. Linearity check in steps of one-ninth of input resistance	110.00
201.102k	Direct reading ratio set, 3 dials	110.00
201.1021	Direct reading ratio set, 4 dials	285.00
201.102m	Double direct reading ratio set	520.00
201.102z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged dependent on the time involved in making the tests.	

RESISTANCE STANDARDS OTHER THAN WIRE-WOUND

§ 201.103 Multi-megohm resistance standards—except wire-wound.

Measurements made on resistors submitted under this section are accurate to 0.1 percent at the time of test if nominal values are in the range 10^6 to 10^{13} ohms; for higher-valued resistors the accuracy is 0.5 percent. In order that the reported results be of significance it is necessary that standards submitted for tests be made of suitable materials processed in such a manner that resistance values do not change rapidly with time. They should be so constructed and treated that the effect of relative humidity is minimized. The resistance of these standards usually depends on the magnitude of the applied voltage; the test voltage should therefore be specified. Each resistor should have an identifying number engraved on or permanently attached to it.

Item	Description	Fee
201.103a	Determination of resistance of a resistor at one voltage (1.5 to 250 V) at room temperature (23° C.) and humidity (50 percent rh or less) when the resistor has a nominal value between 10^9 and 10^{12} ohms	$45.00
201.103b	Determination of resistance of a resistor at one voltage (1.5 to 250 V) at standard laboratory temperature (23° C.) and humidity (50 percent rh or less) when the resistance is higher than 10^{12} ohms but the current involved is not less than 10^{-12} amp	55.00
201.103c	Determination of resistance of a resistor at each voltage (1.5 to 250 V) at standard laboratory temperature (23° C.) and humidity (50 percent rh or less) when the current involved is less than 10^{-12} amp but not less than 10^{-13} amp	70.00
201.103z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged dependent on the time involved in making the tests.	

INDUCTANCE AND CAPACITANCE MEASUREMENTS

NOTE: Tests at radio frequencies are performed at the NBS Boulder Laboratories, Boulder, Colo., 80301.

§ 201.104 Standard inductors.

(a) Inductors for use in a-c bridges are ordinarily tested at 100, 400, 1,000, or 10,000 Hz (c/s) at a room temperature of 23° C. and a relative humidity of 50 percent or less. Measurements at 10,000 Hz (c/s) are limited to standard inductors of 0.1 henry or less. Most inductors used at 60 Hz (c/s) can be tested at 100 Hz (c/s) since the variation of inductance with frequency in this range is usually negligible. Purchase orders should state which frequency or frequencies are to be used for calibration purposes. A metal-encased standard is calibrated with the case connected to the "low" terminal of the inductor unless other conditions are specified. Variable inductors used at circuit elements in laboratory setups are low-accuracy devices which do not come within the purview of this schedule and should not be submitted for calibration. Q values are not supplied for inductors calibrated under this schedule. Inductors intended for use as Q standards at radio frequency should be referred to the Boulder Laboratories. Mutual inductors used in magnetic testing for calibrating ballistic galvanometers should be calibrated with direct current under item 201.403a.

(b) Accuracy: Inductance values and accuracy statements given in reports of calibration depend upon two factors: (1) The accuracy of the comparison of the client's inductor with the NBS working standards of inductance; (2) the uncertainty in the derivation of the unit of inductance which is embodied in the NBS working standards. In general, inductance values will be given to as many significant figures as are justified at the time of measurement. The uncertainty figure given in each report of calibration takes into account factors (1) and (2) stated above and will vary from 0.02 percent to 0.2 percent depending upon the nominal value of the inductor and the frequency of the test current employed.

(c) Inductors can usually be shipped safely by express but should be carefully packed to avoid damage to the coil fastenings and terminals.

Item	Description	Fee
201.104a	Determination of self or mutual inductance of a fixed inductor with non-magnetic core at one frequency, 100, 400, 1,000, or 10,000 Hz (c/s)	$40.00
201.104b	Determination at an additional frequency 100, 400, 1,000, or 10,000 Hz (c/s) on an inductor tested under 201.104a	25.00
201.104z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the calibration.	

§ 201.105 Standard capacitors.

(a) Calibrations are ordinarily performed at 65, 100, 400, 1,000, and 10,000 Hz (c/s) with an ambient temperature of about 23° C. and a relative humidity of 50 percent or less.

(b) The accuracy stated in the report of calibration is determined in part by the accuracy of the NBS measurements and in part by the performance characteristics of the capacitor itself and is sufficiently broad to allow for variations in the stray capacitance at the connectors, variations in temperature of a few degrees Celsius, considerable variation in

relative humidity and atmospheric pressure, and frequency deviations of a few percent from the stated test conditions. Over the above frequency range, and in the capacitance range from 0.001 pF to 100 μF, the uncertainty usually lies in the range 0.002 to 0.5 percent.

(c) The capacitance value given is the equivalent parallel capacitance. In general a determination of the equivalent parallel conductance with high accuracy is not feasible; however, for solid dielectric capacitors an approximate value is given without additional charge.

(d) Continuously adjustable ("variable") capacitors are no longer calibrated by the Bureau.

(e) In applying the following schedule to decade capacitance boxes the first entry (201.105a) applies to a determination of the zero capacitance and conductance of the box (all dials set at zero). The second entry applies to the determination of the capacitance and conductance added to the circuit when any one dial is advanced from zero to a specified setting, and at the frequency used in determining zero capacitance. For measurements at additional frequencies the schedule is applied in the same manner, i.e., the higher fee is used for the first point (zero calibration) at the new frequency, and the lower fee applies to additional points at that frequency.

Item	Description	Fee
201.105a	Determination of either direct or grounded capacitance of a fixed capacitor or one section of a subdivided capacitor, with alternating current at one frequency selected from those listed above (201.105)	$45.00
201.105b	Determination of either direct or grounded capacitance of each additional point on the same subdivided capacitor submitted under item 201.105a	25.00
201.105z	For special calibrations not covered by the above schedule, advance arrangements must be made. Fees will be charged dependent on the time involved in making the calibration.	

Electrochemistry

§ 201.201 Standard cells.

(a) Unsaturated standard cells will be accepted for calibration by the Bureau only from public utilities and others having operations of such a nature as to require calibrations by the Bureau.

(b) Unsaturated cells normally require about two weeks for a complete calibration. The cells are kept in a thermally insulated cabinet and readings of their emf are taken daily for a period of ten days after the values have become reasonably constant. If the emf continues to fluctuate, or is unusually low, or if the cell shows other abnormal indications, the nature of the failure is stated. Unsaturated cells are not likely to be injured by normal transportation (mail or express), if they are carefully packed. Shipment during very cold weather should be avoided because of the possible hazard from freezing.

(c) Saturated cells should be transported by messenger because they should never be inverted nor tipped more than 45°. In order that the reported values are of the highest accuracy the emfs of saturated cells are measured while they are kept 6 to 8 weeks in an NBS temperature-controlled oil bath or in their own thermoregulated air bath.

Item	Description	Fee
201.201a	Cadmium standard cell (unsaturated type), determination of electromotive force with an uncertainty of 0.005 percent	$41.00
201.201b	Cadmium standard cell (saturated type), measurement of the first cell of a group at a fixed temperature of 28° C., in thermostatically controlled oil bath or at a fixed temperature in a thermoregulated air bath	82.00
201.201c	Each additional saturated cell of a group	41.00
201.201d	Cadmium standard cell (saturated type), measurement of the first cell of a group at any temperature between 20 and 35° C., except 28° C., in a thermostatically controlled oil bath	100.00
201.201e	Each additional cell of a group (at temperatures between 20 and 35° C., except 28° C., in a thermostatically controlled oil bath)	48.00
201.201z	For special tests not covered by the above schedule, fees will be charged dependent upon the nature of the test.	

Electrical Instruments

§ 201.300 General.

(a) Indicating (pointer-and-scale) instruments should be calibrated quite frequently with d–c standards and ac–dc transfer instruments, or with stable d–c or a–c sources which are calibrated periodically in this way. Suitable standards and transfer instruments are now readily available commercially. Because of the necessity of frequent tests, a single d–c or a–c calibration of an indicating instrument has little permanent value. Thus in this category the Bureau ordinarily accepts for calibration only rms ac–dc instruments and thermal converters of 0.1 percent rated accuracy or better, for ac–dc difference tests only.

(b) The Bureau's ac–dc difference tests consist of determination of the difference between quantities (current, voltage, or power) required to give the same response (output) of an instrument or thermal converter on alternating current and on reversed direct current, as evaluated by comparison with an NBS ac–dc transfer standard. The alternating quantity, Q_a, required for a given response of the instrument or converter is then $Q_a = Q_d\ (1+S)$ where Q_d is the average quantity required for this response on reversed direct current, as determined by d–c standards, and S is the small fractional ac–dc difference. Usually NBS ac–dc difference tests are made on each range of the instrument or converter. The differences depend on the ratios of the reactances of the components, and increase with frequency, but are small and relatively permanent over the rated frequency range of a well-designed instrument. Therefore, NBS tests are normally made only at the upper rated frequency on each range and at the lower rated frequency on one range. Ordinarily, the tests need not be repeated at intervals of less than five years, and then only if the instrument is to be used over the upper part of its frequency range.

§ 201.301 Standard resistors for current measurements.

(a) *Calibration.* The Bureau normally calibrates only resistors of 0.04 percent accuracy or better. Test results for suitable standard resistors for current measurements are usually reported with an uncertainty of 0.01 percent.

(b) *Design.* A standard resistor for current measurements is a four-terminal resistor, for which the resistance is defined as the ratio of the open-circuit potential difference between the potential terminals to the current through the current terminals. The resistance value will be definite and reproducible only if the current flow pattern at the potential terminals is completely reproduced. This flow pattern should be fixed by resistor design to be independent of the way in which current is introduced at the current terminals and of the location of leads on the potential terminals. In some instances where this has not been done the type and location of connections to the current terminals can be specified adequately to fix the flow pattern at the potential terminals.

(c) *High-current resistors.* (1) Resistors for high currents (above about 1,000 amperes) require considerable power, so that their temperature rise between low and rated current, and the resulting change in resistance, will depend not only on their design, including means provided for dissipating heat, but also on the connecting bus bars and their junctions to the resistor. Bus bars of generous cross section may carry away a significant part of the heat generated in the resistor; inadequate bus bars may actually contribute to the heating of the resistor. In addition, contact resistance at the points of connection to the bus bars, unless carefully minimized, may contribute appreciably to the heating. (Contact resistance of bolted connections depends on area of contact, cleanness of surfaces, and pressure.) Resistance determinations made in the laboratory at rated current may therefore be of little value because the working temperature conditions cannot be duplicated. The best experimental procedure to use in such cases is to place the standard in a temperature-controlled enclosure and measure its resistance with a comparatively low test current when it is heated uniformly to temperatures approximating that at which it will operate in service (201.301 d and e). From data at two or more elevated temperatures, combined with that at room temperature, a curve can be plotted from which the resistance at the operating temperature can be read, provided this temperature is determined by the user with the resistor under the actual operating conditions.

(2) Changes in the resistance may also result from strains in the resistance element produced by mechanical forces incidental to clamping the resistor connections, as well as from inherent internal expansion constraints on resistor parts, or forces from the magnetic field produced by the current.

(d) *Test schedule.* Resistors when first submitted for test should be tested with about 20 percent of rated current and with full rated current; normally when resubmitted for test, determinations need be made only with 20 percent of rated current; once stability is proved, the resistor need not be recalibrated at intervals of less than two years.

Item	Description	Fee
201.301a-1	Initial determination of resistance of a single-range resistor or one range of a multirange resistor, at 30 percent rated current or less (current rating not to exceed 300 amp)	$60.00
201.301a-2	Same as a-1, except current rating above 300 amp but not to exceed 1,000 amp	100.00
201.301b	Determination of resistance on another range of a multirange resistor, at 30 percent rated current or less (current rating not to exceed 300 amp)	20.00
201.301c	Test according to item 201.301a or 201.301b having been made, for an additional determination at another test current (not to exceed 1,000 amp)	30.00
201.301d	Additional determination of resistance at temperatures above room temperature at a current not greater than 30 percent rated, for first elevated temperature	100.00
201.301e	Additional determination of resistance of each additional elevated temperature, at a current not greater than 30 percent rated	24.00
201.301f	Twenty determinations of resistances corresponding to 9 plug positions and 11 slider positions of an adjustable low-resistance standard, at 30 amp	270.00
201.301z	For determinations of resistance at currents larger than 1,000 amp and requiring unusual setups or procedures, and for special tests not covered by the above schedule, advance arrangements must be made. Fees for such tests will depend upon the nature of the test.	

§ 201.302 Volt boxes (fixed ratio voltage dividers).

A volt box is a resistive voltage divider used to extend the range of the voltage measured by a potentiometer. Its ratio for any range is obtained by dividing the voltage across its input terminals by the open-circuit voltage across the section to be connected to the potentiometer.

(a) *Calibration.* The Bureau normally calibrates only volt boxes for which the maker's stated ratio accuracy is 0.04 percent or better. Values of ratio are normally reported with an uncertainty of 0.005 percent.

(b) *Humidity effects.* The insulating structure of a volt box is equivalent to a network of high resistances in parallel with one or more of its wire-wound precision resistance elements. Thus, changes in insulation resistance as a result of variations in surface or volume moisture may affect the ratios. Such ratio changes are normally less on low than on high ratios. This effect can be reduced or eliminated by constructions which provide built-in guard electrodes, maintained at appropriate potentials. Another effect of humidity is to produce changes in the values of the precision wire-wound resistors. The magnitude of this effect varies with coil construction and with wire size and coating. Because humidity effects may reach equilibrium only after days (or even weeks), it is recommended that laboratory humidity be held continuously at or below 50 percent.

(c) *Ambient temperature and self-heating effects.* Changes in ambient temperature should have little effect on ratio if all the resistance elements have the same temperature coefficient. However, self-heating as a result of sustained operation may significantly change the ratios because of unequal temperature rise in the various resistors. The magnitude of this effect depends on construction and coil arrangement, and on the power dissipated. It should (1) be less than for high ranges, (2) be greater for volt boxes that require higher current at rated voltage, (3) increase approximately with the square of the applied voltage, and (4) be entirely negligible at 20 percent of rated voltage on all ranges.

(d) *Suggested test schedule.* (1) Volt boxes should be tested at rated voltage. The first calibration test should also include a test at 20 percent rated voltage on one or more of the higher ranges, which are preferably selected by the Bureau. The equilibrium values at 20 and 100 percent rated voltage may be used to estimate the magnitude of the self-heating effects for the various ranges. Tests having once been made at 20 and 100 percent rated voltage, subsequent determinations need be made only at rated voltage, since the self-heating effect should not change with time.

(2) Once stability has been established, a volt box should not require recalibrations at intervals less than two years.

Item	Description	Fee
201.302a	Determination of ratio on one range at rated voltage, not to exceed 1,500 V, and at a ratio not to exceed 10,000/1	$95.00
201.302b	Determination of ratio at rated voltage on an additional range	20.00
201.302c	Determination at a reduced voltage on a range tested in 201.302 a or b	12.00
201.302d	Test per range, at rated voltage, of a multirange guarded standard voltage divider. (Design similar to that described in NBS RP1419.) Values normally reported with an uncertainty of 0.001 percent	26.00
201.302z	For tests on volt boxes not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the test.	

§ 201.303 Ac–dc instruments and thermal converters (20 to 50,000 Hz (c/s), up to 20 amp and 600 V).

Ordinarily rms ac–dc instruments or converters of 0.1 percent rated accuracy or better are accepted for test, which consists of ac–dc difference determinations by the procedures of items 201.303 a to c. See 201.300.

Item	Description	Fee
201.303a	Initial determination of ac-dc difference of an instrument or converter at one applied voltage or current, one frequency from 20 through 50,000 Hz (c/s)	$50.00
201.303b	Each additional determination of ac-dc difference of the same instrument, converter or set of converters, one frequency from 20 through 20,000 Hz (c/s)	13.00
201.303c	Each additional determination of ac-dc difference of the same instrument, converter, or set of converters, one frequency from 20,000 through 50,000 Hz (c/s)	23.00
201.303z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the test. For tests at higher voltages see 201.604.	

§ 201.304 Ac–dc wattmeters, single phase (20 to 2,000 Hz (c/s), up to 15 amperes and 500 volts).

Ordinarily only single-phase ac–dc wattmeters of 0.1 percent rated accuracy or better are accepted for test, which consists of ac–dc difference determinations by the procedures of items 201.304 a to c. See 201.300. Unless otherwise specified, these tests are made at two scale points at 0.5 power factor on a base range and one scale point at other combinations of ranges, followed by tests at unity power factor at one scale point on one or more ranges, depending upon the results obtained.

Item	Description	Fee
201.304a	Determination of the difference between the reading on reversed direct current and the reading on alternating current at the first scale point at which this difference is determined, at currents not to exceed 15 amp	$58.00
201.304b	Determination of this difference at one scale point on an additional range, frequency, or power factor, at currents not to exceed 15 amp	22.00
201.304c	Determination at each additional scale point with the same combination of range, frequency, and power factor, at currents not to exceed 15 amp	10.00
201.304z	For frequencies greater than 70 Hz (c/s) and for special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the test.	

§ 201.305 Watthour meters.

Except under unusual circumstances, only portable standard watthour meters (rotating standards) will be accepted for test. Tests consist of determinations of the percentage registration of the meter "as received." If meters are to be cleaned and adjusted this must be done before they are submitted for test. The Bureau does not undertake the cleaning and adjustment of meters and does not knowingly begin tests on faulty meters. Before tests can be started the test conditions must be completely specified by the user as to current and voltage ranges to be tested, frequency, applied voltage and current, and power factor. A guide listing a limited yet adequate schedule

of tests is available at no charge. Test voltages should be chosen from the following values: 1, 2, or 4 times 110, 115, 120, 125, and 130 V. Test current should be chosen from the following values: 1, 10, or 100 times 0.25, 0.5, 0.75, 1, 1.25, 1.5, 2, 2.5, 3, 3.75, 4, 5, 7.5 amperes (but not to exceed 100 amperes). Tests at other voltages or currents, or at power factors other than 1.0 and 0.5 current lagging, will be considered as special tests, because rearrangements of circuits are required (see 201.305z). Unless otherwise specified, test runs on portable standard watthour meters (rotating standards) are of approximately 100 seconds duration. The meters are energized for at least 30 minutes at rated voltage and current on one range before starting the test.

Item	Description	Fee
201.305a	Test at 60 Hz (c/s) on one combination of range, applied voltage, and power factor, at not more than five current loads	$72.00
201.305b	Additional test on the same or an additional combination of range, applied current, voltage, and power factor	10.00
201.305c	Test of one or two additional meters simultaneously with the first, under the same conditions as 201.305a, per meter	37.00
201.305d	Test of each additional meter simultaneously with the first, under the same conditions as 201.305b, per meter	6.00
201.305z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the time required for the test.	

§ 201.306 Current transformers.

(a) Calibration: The Bureau normally calibrates only current transformers of high quality for use as reference standards. The Bureau may decline requests for tests which are not to be used for establishing or checking a reference standard. If the transformer quality is stated in terms of ASA accuracy classes, calibration will normally be limited to transformers stated to be in the 0.3 percent class for one or more ASA burdens. Bureau equipment is primarily designed for testing current transformers whose rated secondary current is 5 amperes. Results obtained at frequencies near 60 Hz (c/s) will normally be reported with an uncertainty of 0.05 percent in ratio and 1 min in phase angle. However, in some instances the ratio can be reported with an uncertainty of 0.02 percent and the phase angle to 0.5 minute.

(b) Test information: Tests cannot be started until information is furnished concerning the following conditions: (1) test frequency, (2) secondary test currents, (3) secondary burdens, (4) ranges to be tested. It is customary to make tests at secondary currents of 0.5, 1, 2, 3, 4, and 5 amperes.

(c) Transformer burden: (1) Current transformers should be tested with burdens equivalent to the impedance imposed when the transformer is used as a reference standard. Inclusion of tests at ASA burdens is not recommended. The burdens listed in the American Standard for Instrument Transformers, C–57.13, are for rating purposes only and differ from the instrument burdens imposed on a reference standard. Large errors in measurement can result if the values of ratio and phase angle obtained with an ASA burden are used for the transformer when it supplies only an instrument burden.

(2) Preferably the burden should be specified in terms of the measured resistance and inductance, including the leads to connect the instruments to the secondary of the transformer. If this measurement cannot be made conveniently, it will suffice in most cases to state the name of the maker, the type, range, and serial number of each instrument used in the burden, and the length and size of the leads used in the secondary circuit. Alternatively the burden may be stated in terms of the volt-amperes and power factor of the secondary circuit at the test frequency.

(3) The test equipment regularly used at the Bureau imposes a minimum test burden of about 0.16 ohm with a minimum inductance of about 10 μH (if the burden inductance is larger than 10 μH, the minimum resistance is increased above 0.16 ohm). Special test equipment and procedures must be used for burdens lower than 0.16 ohm, so that advance arrangements must be made and higher fees must be charged. In planning for the tests of a transformer it is therefore desirable to select a low burden, but one larger than this minimum, preferably not less than 0.2 ohm. The required total may be made up by incorporating resistance in the leads to the instruments.

(d) Multirange current transformers, in which the same sections of primary windings are used in series and in parallel, usually have phase angles and ratio factors which are equal on the several ranges to within the accuracy needed for almost any measurement purpose. Hence a test at six values of secondary current on one range is nearly always sufficient to determine the characteristics of the transformer. Further tests, often made at 0.5 and 5 secondary amperes on each additional range, merely serve as a safeguard by means of which mistakes in winding may be detected. When the various ranges of a multirange transformer are obtained by taps on either winding, this relation does not necessarily hold, particularly in the case of secondary taps; and tests in addition to the initial six-point test on one range should be made, using two values of secondary current on each of the ranges so obtained. Transformers of some designs, however, show very little difference in ratio factor and phase angle on the various ranges, and the Bureau should be consulted before tests on a large number of ranges are requested.

(e) Demagnetization: Unless otherwise specified, current transformers will be demagnetized before being tested. If it is desired to have a transformer tested as submitted (without demagnetization), this fact should specifically be stated.

(f) Test limitation at frequencies greater than 60 Hz (c/s): At 400 Hz (c/s), the maximum current range for which tests are made is about 200 amperes and the phase angle values are normally reported to an accuracy of 3 minutes; at 800 Hz (c/s) there is a further reduction in the current range and accuracy. If the burdens at these higher frequencies are specified in terms of volt-amperes and power factor, the frequency for which these values are stated must be clearly indicated so that the proper burden resistance and inductance can be duplicated.

(g) Recalibration: At room temperature the ratio and phase angle under a specified test condition should be repeatable unless the core is magnetized. Once stability has been demonstrated a current transformer should not require recalibration at intervals less than five years.

Item	Description	Fee
201.306a–1	Determinations of the ratio and phase angle of a current transformer on one range at one frequency and one burden (not less than 0.2 ohm resistance) at not more than six values of secondary current, namely, 0.5, 1, 2, 3, 4, and 5 amp unless otherwise specified; primary current not to exceed 500 amp	$115.00
201.306a–2	Same as a–1 except primary current greater than 500 amp but not to exceed 8,000 amp	140.00
201.306b–1	Determinations of the ratio and phase angle at one value of secondary current on an additional combination of frequency, range, and burden (not less than 0.2 ohm resistance); primary current not to exceed 500 amp	20.00
201.306b–2	Same as b–1 except primary current greater than 500 amp but not to exceed 8,000 amp	30.00
201.306c	Determinations of ratio and phase angle at an additional value of secondary current with the same combination of frequency, range, and burden used in 201.306a or b, primary current not to exceed 8,000 amp	10.00
201.306z	For tests of current transformers at frequencies other than 25, 50, or 60 Hz (c/s), or with burdens less than 0.2 ohm resistance, or with primary currents greater than 8,000 amp, and for special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the test.	

§ 201.307 Current transformer comparators (testing sets).

Item	Description	Fee
201.307a	Determination of the values of current ratio and phase angle for settings of the dials of a current transformer comparator for 60 Hz (c/s) (not exceeding 13 points on ratio dial and 15 on on phase angle dial)	$355.00
201.307b	Determination according to 201.307a having been made, for 10 determinations at 25 Hz (c/s) or for determinations on the second range of a double-range comparator	40.00
201.307z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending upon the nature of the test.	

Magnetic Measurements

§ 201.400 General.

(a) A general discussion of magnetic principles and methods used in magnetic testing is given in NBS Monograph 47, Basic Magnetic Quantities and the Measurement of the Magnetic Properties of Materials. Price 30 cents. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

(b) Tests in this field are for the most part made on samples which serve as standards to coordinate work in various laboratories and thus secure uniformity in commercial testing. For this purpose it is essential that the standard bars be very uniform in their magnetic properties. The Bureau does not normally make routine acceptance tests of magnetic materials unless these specimens are to be used, at least temporarily, as standards. The standard dimensions of magnetic test specimens are given in §§ 201.401 and 201.402. It is occasionally possible to test specimens of unusual materials or shapes where the services of the Bureau are needed in the development of new test procedures which are likely to be of importance in the industry. In such cases a full understanding of the problem should be developed by correspondence, or preferably by a visit which will permit direct discussion between engineers concerned and the Bureau staff.

§ 201.401 General magnetic measurements; normal induction and hysteresis.

Specimens submitted for test should be of rectangular cross section, width not to exceed 3.0 cm (1⅛ in.); thickness not to exceed 1.0 cm (⅜ in.); for magnetizing forces from 0 to 300 or 0 to 5,000 oersteds, length to be not less than 25.4 cm (10 in.); for magnetizing forces in the range 100 to 5,000 oersteds, length to be not less than 7 cm (2¾ in.). Specimens whose permeability is not greater than 4 may be of circular cross section, diameter not to exceed 1.27 cm (½ in.) but in any event cross-sectional area must be not less than 0.2 cm^2 (0.031 $in.^2$).

Item	Description	Fee
201.401a	Determination of data for normal induction curve in the range 0 to 300 oersteds	$50.00
201.401b	Determination of data for normal induction curve in the range 100 to 5,000 oersteds	60.00
201.401c	Determination of data for normal induction curve in the range 0 to 5,000 oersteds	100.00
201.401d	Determination of data for demagnetization curve, one value of magnetizing force	60.00
201.401e	Same as 201.401d, each additional value of maximum magnetizing force	40.00
201.401f	Determination of permeability for specimens whose permeability is less than 4, first specimen	20.00
201.401g	Each additional specimen submitted at the same time	10.00
201.401z	For examination of material found to be unsuitable for test, or for special tests not covered by the above schedule, fees will be charged dependent on the cost of such examination or special test.	

§ 201.402 Magnetic materials; a–c permeability and core loss.

Test specimens should consist of the proper number of strips 3 cm (1³⁄₁₆ in.) wide and either 28 cm (11³¹⁄₃₂ in.) to 30.5 cm (12 in.), or 50 cm (19¹¹⁄₁₆ in.) long prepared in accordance with the specifications of the American Society for Testing and Materials, A–34.

Item	Description	Fee
201.402a	Determination of total core loss at 60 Hz (c/s) at one value of maximum induction	$45.00
201.402b	Same as 201.402a, each additional value of maximum induction	15.00
201.402c	Determination of a-c permeability at 60 Hz (c/s) at one value of maximum induction	45.00
201.402d	Same as 201.402c, each additional value of maximum induction	15.00
201.402z	For examination of material found to be unsuitable for test, or for special tests not covered by the above schedule, fees will be charged dependent on the cost of such examination or special test.	

§ 201.403 Magnetic testing apparatus; mutual inductors, search coils, and fluxmeters.

Item	Description	Fee
201.403a	Determination of mutal induction by direct current	$30.00
201.403b	Same at 201.403a, each additional inductor submitted at the same time or each additional value for variable or tapped inductors	15.00
201.403c	Determination of the area-turns of a search coil, first coil	35.00
201.403d	Each additional search coil submitted at the same time	20.00
201.403e	Calibration of fluxmeter at not more than five points on one range	45.00
201.403f	Calibration of fluxmeter at one scale point on an additional range	10.00
201.403g	Calibration of standard magnets	30.00–70.00
201.403z	For examination of apparatus unsuitable for test, or for special tests not covered by the above schedule, fees will be charged dependent on the cost of such examination or special test.	

Dielectric Measurements

§ 201.500 Dielectric constant and dissipation factor.

In general, the Bureau will make tests of insulating and dielectric properties of materials only on (1) specimens of known composition of pure materials for which values are considered of use by the Bureau, or by other government agencies; and (2) dielectric reference standards made from materials exhibiting reproducible behavior under specified environmental conditions (such as humidity), when such standards are needed for improving methods of measurement. Measurements are not made on the effective insulation resistances, dielectric constant or dissipation factor of structures and assemblies of insulation, or on electric breakdown generally. Inquiries giving comprehensive information regarding any tests desired from low frequencies up to 30 kHz (kc/s) should be directed to the National Bureau of Standards, Washington, D.C., 20234. Inquiries concerning tests above 30 kHz (kc/s) should be addressed to the National Bureau of Standards, Boulder, Colo. 80301.

Voltage Ratio and High-Voltage Measurements

Note: See § 201.102 for information relative to the calibration of resistive voltage dividers with direct current. See § 201.302 for information relative to the calibration of volt boxes.

§ 201.601 Voltage dividers.

(a) The calibration of ratio devices such as voltage dividers need not be referred to the national standards of inductance or resistance or to any other national standard. However, methods and equipment are available at the Bureau for the measurement of alternating-voltage ratios with high accuracy, and a routine calibration service for first-quality decade inductive voltage dividers is provided. Inductive voltage dividers which incorporate a resistive divider as a fine adjustment are not accepted for calibration.

(b) The largest contribution to instability in inductive voltage dividers often arises in the decade switches. Variable contact resistance in these switches sometimes affects the stability of voltage-ratio measurements to a significant extent but is most evident by its effect on the phase angle. When a decade inductive voltage divider exhibits large changes in phase angle on repeated measurements after the switches have been disturbed, the divider should no longer be considered satisfactory for use as a standard of voltage ratio.

(c) Corrections for the separate decades of an inductive divider, in general, cannot be simply combined; however, the correction to a step setting of one of the higher decades is usually independent of the setting of the lowest decades. Stray impedances must be fixed by connecting the case to the divider at one point; and unless otherwise specified, the case will be connected to one of the common terminals. Calibration intervals of three years should be satisfactory for good quality inducive voltage dividers which have not been abused.

(d) Decade inductive voltage dividers are calibrated at the Bureau by a comparison method, using as a working standard a well-constructed inductive divider which has previously been calibrated by capacitance-ratio or other suitable methods. The comparison method is simple and convenient and can be used in other laboratories for the rapid calibration of other voltage dividers. Accordingly, it is recommended that, in general, only one divider from a laboratory be submitted to the Bureau for calibration and that other dividers be calibrated by a comparison method using it as a standard.

Item	Description	Fee
201.601a	Determination of the ratio and phase angle of an inductive voltage divider for each setting of the three highest decades (all decades except the one under calibration being set at 0) and for two other arbitrary settings to be selected by NBS, at one frequency (50, 100, 400 and 1,000 Hz (c/s) services are available at NBS Washington; 400 and 1,000 Hz (c/s) services are available at NBS–Boulder) and with an input voltage not exceeding 150 volts rms (calibrations are ordinarily made with an input voltage of 100 volts rms)	$130.00

Item	Description	Fee
201.601b	Determination of the ratio and phase angle of an inductive voltage divider for each setting of the highest decade (all other decades being set at 0) and for one arbitrary setting of each of the 2d and 3d decades to be selected by NBS, at one frequency and with an input voltage not exceeding 150 volts rms (see 201.601a above)	$75.00
201.601z	Determination of the ratios and phase angles of resistive or capacitive voltage dividers and of inductive voltage dividers at frequencies (other than those listed) up to 10 kHz (kc/s) or in other respects beyond those covered in items 201.601a and 201.601b are handled on a special test basis, and advance arrangements must be made. Fees will be charged dependent upon the nature of the test.	

§ 201.602 Voltage transformers.

(a) *Acceptance.* The Bureau normally accepts voltage transformers for calibration only if they are suitable for use as reference standards. Results of tests at or near 60 Hz (c/s) will normally be reported to 0.01 percent in ratio and 1 minute in phase angle.

(b) *Test information.* Tests cannot be started until information is furnished concerning the following test conditions: (1) Test frequency; (2) secondary test voltages; (3) secondary burdens; (4) ranges to be tested.

(c) *Transformer burdens.* The ratio and phase angle of a voltage transformer vary linearly with secondary current under conditions of constant voltage, frequency, and power factor within its rating. Hence, if values of ratio and phase angle are determined on open circuit (zero burden) and at one burden having a particular power factor, values at other burdens with the same power factor (and at the same voltage and frequency) can be found by linear interpolation. If the ratio and phase angle of a voltage transformer are known both on open circuit (zero burden) and at a single unity power-factor burden, the ratio and phase angle for any burden within its rating at any power factor (at the same voltage and frequency) can be computed with sufficient accuracy for many measurement purposes by the following formulas:

$$F = F_0 + \frac{I}{I_1}[(F_1 - F_0)\cos\Phi + (\gamma_1 - \gamma_0)\sin\Phi],$$

and

$$\gamma = \gamma_0 + \frac{I}{I_1}[(F_1 - F_0)\sin\Phi - (\gamma_1 - \gamma_0)\cos\Phi].$$

where I_1 and I are the secondary current at the known unity power-factor burden and the desired burden, respectively; F_0, F_1, and F are the ratio correction factors at zero burden, the known unity power-factor burden, and the desired burden, respectively; γ_0, γ_1, and γ are the corresponding phase angles in radians; and $\cos\Phi$ is the power factor of the desired burden (Φ being taken as positive for inductive burdens). The following conversion factors apply:

1 minute = 0.000291 radian
1 radian = 3438 minutes

The "standard burdens" of the ASA Standard for Instrument Transformers (C57.13) are for rating purposes only, and are not recommended for use as test burdens in calibrating a voltage transformer for use as a reference standard. Values of ratio and phase angle at any ASA burden can be computed with sufficient accuracy for rating purposes by using the above formulas. The test burdens recommended are stated in item 201.602a–1, below. In this item, the instrument burden "to be specified by the user" should preferably be the burden with which the transformer will be used as a reference standard, in the test circuit, and may be stated either in terms of volt-amperes and power factor at a specified voltage and frequency, or the resistance and reactance of the test circuit elements.

(d) *Test voltages.* When a secondary burden of fixed impedance is used, the ratio and phase angle of a well-designed voltage transformer are nearly independent of the secondary voltage within its normal operating range. Hence, tests at a single voltage are sufficient unless the transformer is to be operated over an extended voltage range. In extended-range operation the variations of ratio factor and phase angle with voltage are identical for any constant-impedance burden. Hence, it should be sufficient to make ratio and phase-angle determinations at the extremes of the expected voltage-range of operation and at one or perhaps two intermediate voltage points on one burden (preferably zero burden). Tests at all additional burdens need be made at only a single voltage.

(e) *Multirange transformer.* When multiple ranges are provided by series-parallel primary connections, the ratio correction factors and phase angles (for constant secondary voltage, burden, and frequency) are practically identical for all ranges so obtained. (Hence a single determination on each range after the first serves to completely define the transformer performance when the added ranges are obtained by primary series-parallel combinations.) When multiple ranges are obtained by tapping a portion of one of the windings, or by secondary series-parallel combinations, the ratio correction factors and phase angles are not necessarily the same on the various ranges.

(f) *Fuses.* It is recommended that voltage transformers intended as reference standards be used without fuses, because fuse resistance affects both ratio and phase angle values so that fuse deterioration or replacement may alter the values. When a fused transformer is submitted, tests with the fuses in place will be made only if this is specifically requested by the customer.

(g) *Tests at 400 Hz (c/s).* Ratio and phase angle determinations at 400 Hz (c/s) can be made up to 9,000 volts. Results of such tests will normally be reported to 0.03 percent in ratio and 3 minutes in phase angle.

(h) *Recalibration.* The ratio and phase angle of a voltage transformer for a given burden, voltage, and frequency should not change significantly with time unless the transformer is damaged. Once stability has been demonstrated, a transformer should not require recalibration at intervals less than five years.

(i) *Shipment.* Heavy transformers should be shipped in wooden boxes and held in place, if necessary, by checks or cleats. Large transformers, especially those having oil-filled iron cases, should be crated separately and arranged, whenever possible, so that the terminals can be made accessible for tests without removing the entire crate. The tops of boxes should be marked "this side up." Large transformers (those more than 12 ft. high including crating, or weighing more than 6,000 lbs.) require special handling; advance arrangements, including provision for delivery inside the laboratory, must be made.

Item	Description	Fee
	NOTE: It is recommended that a voltage transformer be calibrated under schedule 201.602a–1 or 201.602a–2 the first time it is submitted to NBS for calibration. In view of the performance characteristics discussed above, it is believed that subsequent calibrations under schedule 201.602a–3 or 201.602a–4 should meet most requirements.	
201.602a–1	Determinations of the ratio and phase angle of a voltage transformer at one frequency (25, 50, or 60 Hz (c/s)), one range, and one secondary voltage, with not more than four values of secondary burden; namely, those giving zero, half, and full rated noninductive load at rated voltage, and with one instrument burden of approximately unity power factor to be specified by the user; primary voltage not to exceed 25,000 V	$110.00
201.602a–2	As in a–1 except primary voltage greater than 25,000 V but not to exceed 100,000 V	150.00
201.602a–3	Determination of the ratio and phase angle of a voltage transformer at one frequency (25, 50, or 60 Hz (c/s)), one range, one secondary voltage and with one unity power factor burden; primary voltage not to exceed 25,000 V	80.00
201.602a–4	Determination of the ratio and phase angle of a voltage transformer at one frequency (25, 50, or 60 Hz (c/s)), one range, one secondary voltage and with one unity power factor burden; primary voltage not to exceed 100,000 V	120.00
201.602b	Determination of ratio and phase angle at one value of secondary voltage on an additional range or frequency, and with any of the burdens used in 201.602a	20.00
201.602c	Determination of ratio and phase angle with an additional burden (already used in 201.602a) and with the same combination of range, frequency, and voltage used in 201.602b	18.00
201.602d	Determination of ratio and phase angle at an additional burden of approximately unity power factor other than those used in 201.602a	30.00
201.602e	Determination of ratio and phase angle at an additional value of secondary voltage on the same combination of range, frequency, and burden used in 201.602 a, b, c, or d	10.00
201.602z	For tests of voltage transformers at other frequencies, with primary voltage greater than 100,000 V, or with other than unity power factor burdens, and for other special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged depending on the nature of the test. At 400 Hz (c/s), test fees are approximately double those at 60 Hz (c/s).	

§ 201.603 Voltage transformer comparators.

Item	Description	Fee
201.603a	Calibrations of voltage transformer comparators are handled on a special test basis; however, advance arrangements need not be made. Fees will be charged dependent upon the nature of the calibration required.	

§ 201.604 Kilovoltmeters.

Item	Description	Fee
201.604a	Calibration of kilovoltmeters at five scale points on one range using 60 Hz (c/s) alternating voltage (up to 60 kV)	$100.00
201.604b	Calibration of kilovoltmeters at five scale points on one range using direct voltage of one polarity to ground (up to 60 kV)	80.00
201.604c	Calibration at one scale point on an additional range (up to 60 kV) for 201.604 a or b	25.00
201.604d	Calibration of each additional scale point on one of the ranges calibrated under 201.604 a, b, or c	10.00
201.604z	For calibrations at voltages above 60 kV, advance arrangements must be made. Fees will be charged dependent upon the nature of the calibration required.	

LOW-FREQUENCY REGION

§ 201.701 Frequency stability calibration of signal sources, up to 30 kHz (kc/s).

(Services available only at the Boulder Laboratories.)

(a) Frequency stability calibrations are made on signal sources up to 30 kHz (kc/s). (See schedule 201.860 for calibration service at higher frequencies.)

(b) The signal source should have a power output of at least 10 milliwatts (into a matched load).

(c) Frequency stability of the signal source should be better than approximately one part in 10^7.

Item	Description	Fee
201.701a	Measurement of frequency stability of signal sources, up to 30 kHz (kc/s)	(*)

*Fees. The fees to be charged for these calibration services performed by the National Bureau of Standards at its Boulder Laboratories, Boulder, Colo., are not fixed at this time. Charges will be made for actual costs incurred. Upon request, estimates will be furnished for specific tasks which should provide a close approximation of actual cost.

HIGH-FREQUENCY REGION

§ 201.800 General.

(a)(1) In the high-frequency region of approximately 30 kHz (kc/s) to 1000 MHz (Mc/s) and higher, the Electronic Calibration Center, Boulder Laboratories, is equipped to calibrate standards of voltage, power, immittance, attenuation, and field strength. These standards are limited at present to those designed for cw measurements and having coaxial terminals (usually type N connectors). No general provisions have yet been made for standards with balanced transmission-line terminals.

(2) Stable rf power sources and detectors are required to perform such measurements. This is accomplished by use of crystal-controlled rf power sources and receivers. Rf power sources have power stabilization circuits that provide a power output constant to within 0.1 percent or better over periods of one hour or more. Special low-noise, crystal-controlled receivers meet the exacting requirements to monitor or detect these signals. In using standards at high frequencies it is often desirable, and even necessary, to duplicate these conditions.

(3) Calibration services for high-frequency standards with coaxial connectors are performed at the fixed frequencies of 30, 100, and 300 kHz (kc/s), and 1, 3, 10, 30, 100, 300, and 1000 MHz (Mc/s). Calibrations are available at other frequencies for some standards, as well as continuous frequency coverage up to 12 GHz (Gc/s) for certain calibrations, but usually with less accuracy.

(4) Connectors limit the accuracy of measurements in the high-frequency region to some extent. To avoid instability from this cause, precision connectors should be used on interlaboratory standards. In the case of Type N connectors, certain mechanical dimensions should fall within tolerances specified by the Armed Services Electro-Standards Agency (ASESA) in Procurement Specification MIL-C-71. If dimensions fall outside the specified tolerances, there is a possibility of damaging the mating connectors on interlaboratory standards and NBS working standards. Critical dimensions of Type N connectors are indicated on a drawing that may be obtained from the Electronic Calibration Center, National Bureau of Standards, Boulder, Colo., 80301.

(b) Fees: The fees to be charged for the following calibration services performed by the National Bureau of Standards at its Boulder Laboratories, Boulder, Colo., are not fixed at this time. Charges will be made for actual costs incurred. Upon request, estimates will be furnished for specific tasks which should provide a close approximation of actual cost.

§ 201.810 Rf, rf–dc voltmeters, and thermal converters in the frequency range of 30 kHz (kc/s) to 1000 MHz (Mc/s); from 0.2 V to 300 V.

Ordinarily instruments equally suitable for use on d–c and rf will be calibrated only for rf–dc difference by the procedure of item 201.810a, since periodic calibrations can be made by the user on reversed direct current. Such reversed d–c calibrations will be made at the Bureau only under unusual circumstances and by advance arrangement. Instruments for use only on rf will be given rf calibrations by the procedures of items 201.810 a, b. Instruments which respond to average or peak values or which are not in ASA accuracy class ¼ percent or better are not usually accepted for calibration below 30 MHz (Mc/s).

Item	Description	Fee
201.810a	Determination of voltage at 30, 100, 300 kHz (kc/s), 1, 3, 10, 30, and 100 MHz (Mc/s) from 0.2 to 300 V	(*)
201.810b	Determination of voltage at 300, 400, 500, 700, and 1000 MHz (Mc/s) from 0.2 to 20 V	(*)
201.810z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.811 Rf micropotentiometers, voltmeters, and signal sources in the frequency range from 30 kHz (kc/s) to 1000 MHz (Mc/s), from 1 μV to 0.1 volt.

The Bureau normally accepts for calibration only high-quality instruments suitable for use as interlaboratory standards. These instruments should have a stability of 1 percent or better and an accuracy of 3 percent or better. Rf voltmeters will be calibrated by the procedures of items 201.811 a, b. The Bureau usually accepts only signal sources (signal generators) high enough in quality to be considered as interlaboratory standards. If these instruments are equally suitable for use on d–c and rf, they will be calibrated for rf–dc difference by the procedures of items 201.811 a, b. Signal sources suitable for use only on rf will be calibrated by the procedure of item 201.811a.

Item	Description	Fee
201.811a	Determination of voltage for micropotentiometers, voltmeters, and signal sources from 30 kHz (kc/s) to 900 MHz (Mc/s), from 1 μV to 0.1 V	(*)
201.811b	Determination of voltage for voltmeters from 900 to 1000 MHz (Mc/s), from 100 μV to 0.1 V	(*)
201.811z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.820 Rf calorimeters, 30 kHz (kc/s) to 500 MHz (Mc/s).

(a) For maximum calibration accuracy, interlaboratory rf calorimeters should repeat readings to one percent or better with a constant power input.

(b) At present only rf calorimeters utilizing Type N connectors for rf power input can be calibrated. Refer to § 201.-800 for special requirements for Type N connectors used on interlaboratory standards.

Item	Description	Fee
201.820a	Calibration of rf calorimeter at one frequency at 100 and 300 kHz (kc/s); 1, 3, 10, and 30 MHz (Mc/s); and at one power level from 0.001 to 200 W	(*)
201.820b	Calibration of rf calorimeter at one frequency at 100, 200, 300, 400, and 500 MHz (Mc/s); at one power level from 0.001 to 100 W	(*)
201.820c	Each additional power level at the same frequency	(*)
201.820z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.821 Continuous wave low-level, power measurement of coaxial bolometer units and bolometer-coupler units.

(a) A bolometer unit includes both the bolometer element or elements and the bolometer mount in which they are supported.

(b) Power measurements are made on barretter-type bolometer units having nominal resistance of 50, 100, or 200 ohms at a bias current between 3.5 and 10 mA; and on thermistor-type bolometer units having a nominal resistance of 50, 100, or 200 ohms at a bias current between 5

and 15 mA. Bolometer units[1] should be of the fixed tuned or untuned broadband type and must have suitable[2] male or female Type N connectors.

(c) Power measurements are made on bolometer units at cw power levels of 1, and 10 mW only.

(d) Power measurements are made on bolometer-coupler combinations having coupling ratios from 3 to 30 dB. A bolometer unit of the fixed tuned or untuned broadband type should be permanently attached to the side arm of the directional coupler. The directional coupler should have good design features, with a directivity of 30 dB or greater, and a VSWR no greater than 1.10 for the input and output ports of the main arm of the coupler.

(e) Effective efficiency for bolometer units is defined as the ratio of the substituted d–c power in the bolometer unit to the microwave power dissipated within the bolometer unit.[3]

(f) Calibration factor for bolometer units is defined as the ratio of the substituted d–c power in the bolometer unit to the rf power incident upon the bolometer unit.[3]

(g) Calibration factor for bolometer-coupler units is defined as the ratio of the substituted d–c power in the bolometer unit on the side arm of the directional coupler to the rf power incident upon a nonreflecting load attached to the output port of the main arm.[3]

(h) For temperature-compensated bolometer units, the d–c cable may be sent with the unit for maximum accuracy of calibration.

Item	Description	Fee
201.821a	Measurement of calibration factor of a coaxial bolometer unit at one frequency at 100 MHz (Mc/s) or 1 GHz (Gc/s); and at one power level, 1 or 10 mW	(*)
201.821b	Measurement of calibration factor of a coaxial bolometer-coupler unit at one frequency at 30, 100, 200, 300, 400, 500 MHz (Mc/s), or 1 GHz (Gc/s); and at one power level	(*)
201.821c	Each additional power level at the same frequency	(*)
201.821z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.830 Immittance, 30 kHz (kc/s) to 4 GHz (Gc/s).

(a) Maximum accuracy can be achieved only in the case of instruments and components equipped with connectors having a plane of reference directly compatible with the Bureau system with no necessity for special adapters. In the interest of preserving higher calibration accuracies, coaxial connectors should be utilized on standard instruments and components wherever possible. Calibrations are not performed on capacitors with unshielded terminals, e.g. binding posts and banana plug connectors.

(b) Power applied to any item under test will normally not exceed 1 W. Where caution in this respect is necessary it should be clearly stated in the calibration request. All calibrations described in this section are performed under ambient conditions of approximately 23° C. and 40 percent relative humidity.

Item	Description	Fee
201.830a–1	Two-terminal impedance measurement at one point in the frequency range 30 to 400 kHz (kc/s), 0 to 10,000 ohms resistance, and 0 to 1100 μH inductance	(*)
201.830a–2	Each additional point within the limits in item 201.830a–1	(*)
201.830b–1	Two-terminal impedance measurement at one point in the frequency range 30 kHz (kc/s) to 1 MHz (Mc/s), 0 to 1000 ohms resistance, and 0 to 110 μH inductance	(*)
201.830b–2	Each additional point within the limits in item 201.830b–1	(*)
201.830c–1	Two-terminal admittance measurement at one point in the frequency range 30 kHz (kc/s) to 1 MHz (Mc/s), 0 to 1100 μmho conductance, and 0 to 1100 pF capacitance	(*)
201.830c–2	Each additional point within the limits in item 201.830c–1	(*)
201.830d–1	Two-terminal admittance measurement at one point in the frequency range 5 to 250 MHz (Mc/s), 0 to 50 μmho conductance, and 0 to 50 pF capacitance	(*)
201.830d–2	Each additional point within the limits in item 201.830d–1	(*)
201.830e–1	Two-terminal impedance measurement of coaxial components at frequencies from 50 MHz (Mc/s) to 4 GHz (Gc/s), within the range 0.5 to 5000 ohms for magnitude and 0 to 90° for phase angle	(*)
201.830e–2	Each additional point within the limits in item 201.830e–1	(*)
201.830f–1	Q-Standard calibration in the frequency range 50 kHz (kc/s) to 45 MHz (Mc/s), 0 to 1000 for effective Q, and 30 to 450 pF for effective resonating capacitance	(*)
201.830z	Special two-terminal immittance calibrations not covered by the above schedule	(*)
201.831a–1	Three-terminal capacitance calibration at 100 kHz (kc/s), 455 kHz (kc/s), or 1 MHz (Mc/s) for the following fixed nominal values: 10^{-2}, 10^{-1}, 10^{0}, 10^{1}, 10^{2}, and 10^{3} pF, per frequency	(*)
201.831b–1	Three-terminal capacitance calibration at 465 kHz (kc/s) at one point in the range 0.001 to 100 pF	(*)
201.831b–2	Each additional point within the limits in item 201.831b–1	(*)

*See § 201.800(b). Fees.

§ 201.840 Dissipative fixed coaxial attenuators.

(a) Dissipative fixed coaxial attenuators are normally calibrated in a system having a characteristic impedance of 50+j0 ohms. Since the accuracy of the calibration is degraded by any deviation or uncertainty in this characteristic impedance, the types of allowable connectors are limited. Precision connectors having a known plane of reference or the Type N meeting Procurement Specification MIL–C–71 are required. (See § 201.800.) All measurements are made by the substitution method which requires that the connectors used be asexual or the attenuator have a male connector at one port and a female connector at the other port. If an adapter is required to comply with the foregoing, it must be supplied with the attenuator and the combination will be calibrated as one unit. Attenuators having a VSWR of 1.30 or greater at either port are not acceptable.

(b) Maximum power to any attenuator will not exceed 20 mW unless prior arrangements for higher power levels have been made.

Item	Description	Fee
201.840a–1	Measurement of insertion loss of fixed attenuator at one of the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s). Range: 0 to 100 dB	(*)
201.840a–2	Each additional attenuator at the same frequency and over the same range as item 201.840a–1	(*)
201.840b–1	Measurement of insertion loss of fixed attenuator at any frequency between 200 MHz (Mc/s) and 12 GHz (Gc/s). Range: 0 to 60 dB	(*)
201.840b–2	Each additional attenuator at the same frequency and over the same range as item 201.840b–1	(*)
201.840z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.841 Dissipative variable coaxial attenuators.

(a) These attenuators are calibrated in accordance with item 201.840 except that the zero or other specified setting is used as the reference. Because attenuation difference only is measured, both ports may have the same connector.

(b) Variable attenuators must have a repeatability of setting better than 0.1 dB; incremental attenuators must have a repeatability of 0.01 dB or better.

Item	Description	Fee
201.841a–1	Measurement of one increment on dissipative variable attenuator or at one of the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s). Range 0 to 100 dB	(*)
201.841a–2	Each additional increment at the same frequency and over the same range as item 201.841a–1	(*)
201.841b–1	Measurement of one increment on a dissipative variable attenuator at any frequency between 200 MHz (Mc/s) and 12 GHz (Gc/s). Range 0 to 60 dB	(*)
201.841b–2	Each additional increment at the same frequency and over the same range as item 201.841b–1	(*)
201.841z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.842 Waveguide below-cutoff (piston) attenuators.

(a) Waveguide below-cutoff attenuators are normally calibrated in a system having a characteristic impedance of 50+jO ohms. As only attenuation difference measurements are made on this type of attenuator, Type BNC, C, TNC, etc., connectors are acceptable but precision type connectors are preferred.

(b) An insertion loss measurement at the attenuator zero setting can be made. Maximum power to any attenuator will not exceed 20 mW unless prior arrangements for higher power levels have been made.

(c) Calibrations are performed at the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s).

[1] Bolometer unit is here defined to include the bolometer element and the bolometer mount.

[2] See § 201.800.

[3] Desch, R. F., and R. E. Larson, Bolometric Microwave Power Calibration Techniques at NBS, IEEE Trans-I&M, IM–12, No. 1, 29 (June 1963).

Item	Description	Fee
201.842a-1	One increment on a waveguide below-cutoff attenuator at one of the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s). Range (including initial insertion loss): up to 110 dB	(*)
201.842a-2	Each additional increment at the same frequency and over the same range as item 201.842a-1	(*)
201.842z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.843 Coaxial fixed directional couplers.

Fixed directional couplers are calibrated in accordance with item 201.840. Terminations must be supplied for any arm not used during a measurement.

Item	Description	Fee
201.843a-1	Single insertion loss measurement between any two arms of a coaxial fixed directional coupler at one of the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s). Range: 0 to 100 dB	(*)
201.843a-2	Each additional insertion loss measurement between any two arms at the same frequency and over the same range as item 201.843a-1	(*)
201.843b-1	Single insertion loss measurement between any two arms at any frequency between 200 MHz (Mc/s) and 12 GHz (Gc/s). Range: 0 to 60 dB	(*)
201.843b-2	Each additional insertion loss measurement between any two arms at the same frequency and over the same range as item 201.843b-1	(*)
201.843z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.844 Coaxial variable directional couplers.

(a) Coaxial variable directional couplers are calibrated in accordance with item 201.841. Terminations must be supplied for any arm not used during a measurement.

(b) The change in coupling to the side arm relative to the minimum setting on the device is normally measured.

Item	Description	Fee
201.844a-1	Single coupling increment between input and variable arm of coaxial variable directional coupler at one of the following frequencies: 1, 10, 30, 60, 100, and 300 MHz (Mc/s). Range (including initial coupling loss): up to 110 dB	(*)
201.844a-2	Each additional increment at the same frequency, and over the same range as item 201.844a-1	(*)
201.844b-1	Same measurement as in item 201.844a-1 at any frequency between 200 MHz (Mc/s) and 12 GHz (Gc/s). Range (including initial coupling loss): up to 60 dB	(*)
201.844b-2	Same measurement as in item 201.844a-2 at the same frequency and over the same range as item 201.844b-1	(*)
201.844z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.850 Field strength meters, 30 Hz (c/s) to 1000 MHz (Mc/s).

(a) Field strength standards and field strength meters are calibrated in terms of cw signals in the frequency range from 30 Hz (c/s) to 1000 MHz (Mc/s). Loop antennas are calibrated in the frequency range from 30 Hz (c/s) to 30 MHz (Mc/s), and horizontally polarized dipole antennas are calibrated from 30 to 1000 MHz (Mc/s). The magnitude of the calibrating fields varies from approximately 25 to 200 mV/m for loop antennas, and approximately 50 mV/m for dipole antennas.

(b) The internal characteristics of field strength meters, such as the overall linearity of the receiver, accuracy of the signal input attenuators, and the accuracy of the receiver as a two-terminal rf voltmeter can be measured at frequencies from 30 Hz (c/s) to 1000 MHz (Mc/s).

(c) When field strength standards or meters are submitted for calibration an instruction manual and all accessories should be included, and the instrument should be in excellent operating condition.

Item	Description	Fee
201.850a-1	Calibration of loop antenna at one frequency, 30 Hz (c/s) to 30 MHz (Mc/s)	(*)
201.850a-2	Calibration of loop antenna at frequencies additional to item 201.850a-1, 30 Hz (c/s) to 30 MHz (Mc/s)	(*)
210.850z	Special calibrations not covered by the above schedule	(*)
210.851a-1	Calibration of dipole antenna at one frequency, 30 to 1000 MHz (Mc/s)	(*)
201.851a-2	Calibration of dipole antenna at frequencies additional to item 201.851a-1, 30 to 400 MHz (Mc/s)	(*)
201.851a-3	Calibration of dipole antenna at frequencies additional to item 201.851a-1, 400 to 1000 MHz (Mc/s)	(*
201.851z	Special calibrations not covered by the above schedule	(*)
201.852a-1	Calibration of input attenuators at one frequency, initial step	(*)
201.852a-2	Calibration of additional steps of input attenuator in addition to item 201.852a-1	(*)
201.852b-1	Calibration of the overall linearity of receiver and output circuit at one frequency and one attenuator setting, initial point	(*)
201.852b-2	Calibration of overall linearity of receiver at other points in addition to item 201.852b-1	(*)
201.852c-1	Calibration of the receiver as a two-terminal rf voltmeter, 1 to 10,000 μV, 0 to 400 MHz (Mc/s), at one frequency	(*)
201.852c-2	Calibration of the receiver as a two-terminal rf voltmeter at other frequencies additional to item 201.852c-1, 0 to 400 MHz (Mc/s)	(*)
201.852c-3	Calibration of receiver as a two-terminal rf voltmeter at other frequencies additional to item 201.852c-1, 400 to 1000 MHz (Mc/s)	(*)
201.852z	Special calibrations not covered by the above schedule	(*)

*See § 201.800(b). Fees.

§ 201.860 Frequency stability calibration of signal sources.

(Service available only at the Boulder Laboratories.)

(a) Frequency stability calibrations are made on signal sources in the frequency range from 30 kHz (kc/s) to 500 MHz (Mc/s).

(b) The signal source should have a power output of at least 10 milliwatts (into a matched load).

(c) Frequency stability of the signal source should be better than approximately one part in 10^7.

Item	Description	Fee
201.860z	Measurement of frequency stability of signal sources, from 30 kHz (kc/s) to 500 MHz (Mc/s)	(*)

*See § 201.800(b). Fees.

Microwave Region

§ 201.900 General.

(a)(1) Microwave calibration services presently available include measurements in power, impedance, frequency, attenuation, and noise. The frequency range covered for each of the measurements is given below.

(2) In performing microwave calibrations, a considerable amount of time is needed to prepare the system for measurement operation. Much of this preparation is related to the adjustment of the system to the frequency of operation selected for the calibration. Time and cost often can be reduced by minimizing the number of times the operating frequency of the calibration system must be readjusted. To help in achieving this reduction in costs, a list of suggested calibration frequencies is presented in the following table. These frequencies are suggested for use in connection with this schedule and for interlaboratory standards utilizing terminations consisting of the standard waveguide sizes given below in the table of suggested calibration frequencies. It should be emphasized that the suggested frequencies are primarily for economy and for convenience to those requesting calibrations. In general the calibration instrumentation for the microwave region is intended to provide complete and continuous frequency coverage as appropriate for the various waveguide sizes. Those having need for calibrations at other than suggested frequencies can be accommodated.

EIA waveguide designation	Frequency range GHz (Gc/s)	Suggested calibration frequencies GHz (Gc/s)		
		No. 1	No. 2	No. 3
WR284	2.60- 3.95	2.85	3.25	3.55
WR187	3.95- 5.85	4.35	4.90	5.25
WR137	5.85- 8.20	6.45	7.00	7.40
WR112	7.05-10.0	7.75	8.50	9.00
WR90	8.20-12.4	9.00	10.50	11.2
WR62	12.4 -18.0	13.5	15.0	17.0
WR42	18.0 -26.5	19.8	22.0	23.8
WR28	26.5 -40.0	29.0	33.0	37.0

(b) Fees: The fees to be charged for the following calibration services performed by the National Bureau of Standards at its Boulder Laboratories, Boulder, Colo. are not fixed at this time. Charges will be made for actual costs incurred. Upon request, estimates will be furnished for specific tasks which should provide a close approximation of actual costs.

§ 201.910 Continuous low-level, power measurement of waveguide bolometer units and bolometer-coupler units.

(a) Power measurements are made on barretter-type bolometer units having

nominal resistance of either 100 or 200 ohms at a bias current between 3.5 and 10 mA, and on thermistor-type bolometer units having a nominal resistance of either 100 or 200 ohms at a bias current between 5 and 15 mA. Bolometer units should be of the fixed tuned or untuned broadband type.

(b) Power measurements are made on bolometer units at power values from 0.1 to 10 mV.

(c) Power measurements are made on bolometer-coupler combinations having coupling ratios from 3 to 20 dB. A bolometer unit of the fixed tuned or untuned broadband type should be permanently attached to the side arm of the coupler. The three-port directional coupler should have good design features with a directivity of 40 dB or greater and a VSWR no greater than 1.05 for the input and output ports of the main arm of the coupler.

(d) Effective efficiency for bolometer units is defined as the ratio of the substituted d–c power in the bolometer unit to the microwave power dissipated within the bolometer unit.

(e) Calibration factor for bolometer units is defined as the ratio of the substituted d–c power in the bolometer unit to the microwave power incident upon the bolometer unit.

(f) Calibration factor for bolometer-coupler units is defined as the ratio of the substituted d–c power in the bolometer unit on the side arm of the directional coupler to the microwave power incident upon a nonreflecting load attached to the output port of the main arm.

(g) Efficiency for bolometer units is defined as the ratio of the microwave power absorbed by the barretter element to the microwave power dissipated within the bolometer unit.

Item	Description	Fee
	Measurement of effective efficiency of bolometer unit at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.910a–1	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.910a–2	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.910a–3	WR137 (5.85–8.20 GHz) (Gc/s)	(*)
	Measurement of calibration factor of bolometer unit at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.910b–1	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.910b–2	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.910b–3	WR 137 (5.85–8.20 GHz)(Gc/s)	(*)
	Measurement of calibration factor of bolometer coupler unit at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.910c–1	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.910c–2	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.910c–3	WR137 (5.85–8.20 GHz) (Gc/s)	(*)
	Measurement of efficiency of bolometer unit at a single frequency of the following waveguide size terminated with a standard waveguide connector:	
201.910d–3	WR137 (5.85–8.20 GHz) (Gc/s)	(*)
201.910z	Special calibrations not covered by the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.911 Continuous low-level power measurement of waveguide dry calorimeters.

Item	Description	Fee
201.911a–1	Measurement of output voltage versus input microwave power for dry calorimeter at a single frequency of WR90 waveguide (8.2–12.4 GHz (Gc/s) terminated with a standard waveguide connector, at power values from 10 milliwatts to 1 watt	(*)
201.911a–2	Each additional power value at the same frequency as item 201.911a–1	(*)
201.911z	Special calibrations not covered by the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.920 Reflection coefficient magnitude measurement on waveguide reflectors (mismatches).

(a) Reflection coefficient measurements are made on reflectors producing a reflection coefficient magnitude in the range 0.025 to 1.0.

(b) Reflectors must be fitted with standard types of waveguide flanges. The face of these flanges should be machined flat and smooth and should not contain protrusions or indentations. The connecting holes of the flange should be symmetrically and accurately alined to the rectangular waveguide opening.

Item	Description	Fee
	Measurement of reflection coefficient magnitude of reflector at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.920a–1	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.920a–2	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.920z	Special calibrations not covered by the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.930 Frequency measurement on cavity wavemeters.

(a) Frequency measurements are made on fixed or variable cavity wavemeters of either the reaction (one-port) type or the transmission (two-port) type.

(b) Frequency measurements are made on fixed or variable cavity wavemeters having coaxial terminals with Type N connectors (male or female) in the frequency range of 1000 MHz (Mc/s) to 10 GHz (Gc/s).

(c) Frequency measurements are made on fixed or variable cavity wavemeters having standard type waveguide terminals in the frequency range of 2.6 to 75 GHz (Gc/s).

Item	Description	Fee
201.930a	Measurement of resonance frequency of fixed cavity wavemeter	(*)
201.930b	Setting of adjustable cavity wavemeter at prescribed resonance frequency	(*)
201.930c–1	Calibration of dial setting versus resonance frequency of variable cavity wavemeter at initial prescribed frequency	(*)
201.930c–2	Calibration of dial setting versus resonance frequency of variable cavity wavemeter at each prescribed frequency additional to the initial frequency and on the same wavemeter as 201.930c–1	(*)
201.930z	Special calibrations not covered by the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.940 Attenuation difference measurements on variable attenuators.

(a) Attenuation difference measurements are made on step or continuously variable attenuators usually with the zero dial setting used as the reference position.

(b) Attenuation measurements are made for attenuation values from 0 to 50 dB. This range of attenuation values can be extended to 70 dB in some frequency ranges.

(c) Variable attenuators should have a repeatability of dial setting better than ±0.1 dB.

(d) Variable attenuators should have a VSWR less than 1.1 at each waveguide port.

Item	Description	Fee
	Measurement of attenuation difference of direct-reading variable attenuator at an initial prescribed dial setting at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.940a–1	WR284 (2.60–3.95 GHz) (Gc/s)	(*)
201.940a–2	WR187 (3.95–5.85 GHz) (Gc/s)	(*)
201.940a–3	WR137 (5.85–8.2 GHz) (Gc/s)	(*)
201.940a–4	WR112 (7.05–10.0 GHz) (Gc/s)	(*)
201.940a–5	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.940a–6	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.940a–7	WR42 (18.0–26.5 GHz) (Gc/s)	(*)
201.940a–8	WR28 (26.5–40.0 GHz) (Gc/s)	(*)
201.940a–20	Measurement of attenuation difference of direct-reading variable attenuator at each prescribed dial setting additional to the initial dial setting at the same frequency and on the same attenuator as 201.940a–1 to 201.940a–8	(*)
	Calibration of dial setting versus attenuation difference for indirect-reading variable attenuator at an initial prescribed attenuation difference value at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.940b–1	WR284 (2.60–3.95 GHz) (Gc/s)	(*)
201.940b–2	WR187 (3.95–5.85 GHz) (Gc/s)	(*)
201.940b–3	WR137 (5.85–8.2 GHz) (Gc/s)	(*)
201.940b–4	WR112 (7.05–10.0 GHz) (Gc/s)	(*)
201.940b–5	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.940b–6	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.940b–7	WR42 (18.0–26.5 GHz) (Gc/s)	(*)
201.940b–8	WR28 (26.5–40.0 GHz) (Gc/s)	(*)
201.940b–20	Calibration of dial setting versus attenuation difference for indirect-reading variable attenuator at each prescribed attenuation difference value additional to the initial attenuation difference value at the same frequency and on the same attenuator as 201.940b–1 to 201.940b–8	(*)
201.940z	Special calibrations not included in the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.941 Insertion loss measurements on fixed attenuators.

(a) Insertion loss measurements are made on fixed two-port attenuators.

(b) Insertion loss measurements are made for insertion loss values from 0 to 50 dB. This range of attenuation values can be extended to 70 dB in some frequency ranges.

(c) Fixed attenuators should have a VSWR less than 1.1 at each waveguide port.

Item	Description	Fee
	Measurement of insertion loss of fixed attenuator at a single frequency of the following waveguide sizes terminated with standard waveguide connectors:	
201.941a–1	WR284 (2.60–3.95 GHz) (Gc/s)	(*)
201.941a–2	WR187 (3.95–5.85 GHz) (Gc/s)	(*)
201.941a–3	WR137 (5.85–8.2 GHz) (Gc/s)	(*)
201.941a–4	WR112 (7.05–10.0 GHz) (Gc/s)	(*)
201.941a–5	WR90 (8.2–12.4 GHz) (Gc/s)	(*)
201.941a–6	WR62 (12.4–18.0 GHz) (Gc/s)	(*)
201.941a–7	WR42 (18.0–26.5 GHz) (Gc/s)	(*)
201.941a–8	WR28 (26.5–40.0 GHz) (Gc/s)	(*)
201.941z	Special calibrations not included in the above schedule	(*)

*See § 201.900(b). Fees.

§ 201.950 Effective noise temperature measurement on noise sources.

(a) Effective noise temperature measurements are made on waveguide noise sources (usually a gas-discharge tube) under conditions of continuous, unmodulated operation in the range 900 to 300,000° K. (excess noise ratio range 3.3 to 30 dB).

(b) The direct current required for normal operation of the gas-discharge tube should not exceed 300 mA but should be sufficient to prevent excessive plasma oscillations.

(c) The waveguide noise source must have an input VSWR no greater than 1.2.

(d) The gas-discharge tube should be secure in the mount, and the output port of the unit should be terminated with a matched load.

Item	Description	Fee
201.950a–1	Measurement of effective noise temperature of noise source in WR90 waveguide at a single frequency selected from 9.0, 9.8, and 11.2 GHz (Gc/s)	(*)
201.950z	Special calibrations not covered by the above schedule	(*)

*See § 201.900(b). Fees.

A. V. ASTIN,
Director.

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